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Psychological Laboratories

M.I.T.

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Work in behavioral biology in the Psychology Laboratories during the last six months has proceeded, as in the past, in three distinct but overlapping areas, viz., brain and behavior (physiological psychology), perception and learning (general experimental psychology), and comparative and developmental studies (with continued emphasis on early stages in the development of perception and coordinated motor function in animal and man, and on the acquisition of language and logic in children).

I. Brain and Behavior

Investigations in this area have been concerned with the search for neural correlates of perception, learning and sensorimotor coordination.

A. Neural Correlates of Perception

In recent work we have been able to extend earlier distinctions among those neural mechanisms which seemed to play an essential role in the origin and maintenance of spatial organization in perception (see, e.g., Held, 1964a, 1965; Teuber, 1964a,b). Integrity of primary sensory pathways appears to be essential for the presentation of sensory input, but there is increasing evidence for extensive categorizing of these inputs, or "preprocessing" of sensory information within the primary pathways. By contrast, frontal lobes and basal ganglia, particularly the caudate nucleus, appear to play a rather crucial role in perceptual compensation, i.e., in the maintenance of spatial order in perception during those changes of the input that are consequences of changing posture, as during voluntary movement (Teuber, 1964a; Teuber and Proctor, 1964). Lastly, parietal structures appear to be essential for the proper representation of space, i.e., the maintenance of orientation to one's own body and to the environment.

1. Accordingly, recent studies in these laboratories have further explored those changes in the presentation of visuo-spatial order which occur in the presence of acquired gaps in the visual field. Highly redundant geometric patterns have been employed as well as computer-generated "visual noise." Several new forms of completion effects across such gaps (scotomata) have been demonstrated, including completion for visual noise. There has been additional work on visual evoked responses obtained by computer averaging in normal adults and in those with lesions of the visual pathways, as well as in monkeys with unilateral surgical interruption of these pathways or with occipital-lobe resections (see Vaughan, 1965; Vaughan and Hull, 1965).

2. Continued work on frontal-lobe or basal-ganglia lesions in man (see also Chorover and Cole, 1965) includes a reanalysis and redesign of those visual searching tests which had previously revealed quite specific signs of frontal dysfunction in the form of a breakdown in visuo-motor control. Efforts continue to identify methods for the tracking of voluntary eye movements during active search, and to do this without the need for attaching recording devices to the subject's eye or face (Iseri, 1965). If perfected, such methods would provide a basis for constructing a perimeter which would not require that the subject maintain fixation - a

method particularly suitable for obtaining visual fields in monkeys, children, or in adults unable to follow the necessary instructions for perimetry.

3. Finally, it has been shown that relatively small parietal-lobe lesions in adults can produce a failure of tactile form perception in the absence of primary tactile deficits but associated with more general spatial disorientation, as shown in a selective impairment of route finding by use of maps (Semmes, work in progress). Correspondingly selective impairment of performance by rodents in certain open field mazes has been shown to follow posterior cortical removals (Gross, Chorover and Cohen, 1965).

B. Neural Correlates of Learning

In addition to the ongoing work on the neural bases of perception and coordination there have been continuing efforts at identifying some of the neural correlates of learning. In this connection, those basal brain lesions in man which produce selective defects in retention and recall of recently learned material are being contrasted with the quite different effects of lesions impinging on the convexity of the forebrain. Studies of learning in subhuman forms have likewise been continued (Chorover, 1964; Chorover and Schiller, 1965a,b,c), demonstrating once again that the so-called "consolidation of memory traces," after one-trial learning in rodents, is an exceedingly brief affair (the memory being fixed after 1-2 seconds), and that stimulation through implanted electrodes in cats and rats can interfere with memory consolidation, if such intracerebral stimulation is applied at critical sites within 2 seconds or less after a given learning trial (Mahut, 1964).

Neurochemical and autoradiographic studies (Altman, 1964, 1965) have confirmed that rearing of rats in so-called "enriched environments" (permitting increased exploratory activity) leads to increased proliferation of glial elements in their cerebral cortex (Altman and Das, 1964). Work employing similar methods deals with sequential appearance of various cell types in the hippocampus soon after birth (Altman and Das, 1965), and with the question of selective incorporation of various labelled substances, including steroids, into this important structure which has been implicated by earlier behavioral studies in emotional expression and in learning (Pfaff, 1965).

C. Neural Bases of Motor Control

A persistent problem in the interpretation of cerebral function derives from the limited and stereotyped ways in which the neuroanatomy of central pathways and regions tends to be presented. The classical view draws sharp contrasts between sensory and motor systems and traces nearly all activity exclusively from the former to the latter (but see Nauta, 1964, 1965; Taub, 1964). On this schema, the role of the limbic structures of the forebrain in impelling or inhibiting action becomes all but incomprehensible. Similarly, non-classical pathways leading from supposedly motor to supposedly sensory regions within the brain - by direct, central routes - tend to be overlooked. Accordingly, a critical review of current conceptions of the anatomy and physiology of cerebral motor systems has been undertaken at the end of the period covered by this report in the form of an all-day conference (see Appendix). The laboratory thus continues to be concerned with the identification of neural pathways for those compensatory mechanisms ("corollary discharge") which presumably accompany all voluntary motor activities. We postulate that efferent signals sent to the voluntary musculature are associated with a second set of signals addressed from motor to sensory systems, pre-setting the latter for those changes in afferent input which the organism can expect to result from performing the motion (Teuber, 1964a).

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II. Perception and Learning

Ongoing work in experimental psychology within the framework of this program is focussed on the same issues which have just been considered under their physiologic aspects - problems of perception, learning, and sensorimotor coordination.

A. Sensorimotor Control under Extreme Conditions

Thus, a central question in the analysis of perception concerns the stimulus conditions which enable the perceiver to remain properly oriented during the continual transformations of the visual scene, and of other sensory inputs, while he moves actively about (Held, 1964a,b; 1965a; Teuber, 1964a,b). This sensorimotor coordination represents a complex achievement whose origin and maintenance requires intensive study. A principal approach to the study of visuo-motor coordination is to produce its temporary decay under certain experimental conditions in the normal adult.

1. One of these conditions employs artificially imposed changes in the spatial or temporal relations between the motor output of the perceiver (e.g., his locomotion or tracking performance) and the corresponding reafferent sensory input (see Bauer and Efstathiou, 1965; Hein, 1965; Held, 1965b). These input distortions can be obtained through displacing spectacles (spatial distortion) or through delay lines introducing various time delays into the visual display of the perceiver's own pointing or tracking performance (temporal distortion).

2. An alternative way of decorrelating the normal sensorimotor feedback loop employs tracking tasks in which the subject works against variable force (Abplanalp and Held, 1965), i.e., under conditions similar to radial locomotion in a spinning space capsule or in a decelerating capsule during re-entry and re-appearance of gravitational effects upon the astronaut. Important theoretical and practical issues remain to be investigated, particularly concerning the speed and limit of adaptation to varying g-forces during the execution of tasks requiring precise sensorimotor control.

It should be pointed out that the results of ongoing experiments on sensorimotor coordination within this program continue to support the view that self-produced movement is a major factor in mediating adaptation to prisms and other distorting devices (see Held and Mikaelian, 1964; Held and Schlank, 1964; Hochberg and Held, 1965); the same results strengthen our belief that self-produced movement is just as important in the origin of normal sensorimotor coordination, so that early perceptual development, in animal and man, could be stunted by "motor deprivation" in spite of seemingly normal sensory input.

B. Studies of Normal Vision

Other studies of normal perception continue to deal with the problems of time estimates (Richards, 1964), and with the stimulus determinants of brightness and color. It could be shown that brightness enhancement of an interrupted light at low rates of intermittence can be entirely explained by the Broca-Sulzer effect, i.e., the optimal effectiveness of single flashes at a given duration, with shorter and longer flashes producing less brightness (see Wasserman, 1964, 1965a,b). These optimal durations are being explored systematically for different wavelengths, with

results for man conforming quite closely to predictions derived from earlier studies by others on various slow potentials in the isolated fish retina.

In a direct test of the major theories of human color vision, a computer program has been written and applied to obtain a uniform color space (Richards, 1964, 1965). The conclusions are incompatible with the traditional forms of tri-receptor as well as opponent-process theories, but favor a modified opponent-process view as incorporated in a stage theory, such as that of Müller and von Kries (see also Richards and Luria, 1964).

Temporal factors in visual perception are being explored primarily through studies of short-term interactions, as shown in various forms of masking, especially the partial or complete interference with detection of a visually presented pattern by another pattern presented soon afterwards (see Schiller, 1965a, b,c; Schiller and Smith, 1965). This approach has now been extended to direct experimental comparison of so-called forward with backward masking, i.e., the effects of a preceding pattern on the detectability of one that follows very soon thereafter. Both effects have currently come under scrutiny by those who claim that forward and backward masking result from the same process, namely contrast reduction, and hence diminution of opportunity for forming distinct contours. Current experiments in these laboratories indicate, however, that the two forms of masking are nonetheless different, both in magnitude of the interference effects and in the processes that lead to them, with the proactive effects (forward masking) lasting much longer than the retroactive ones.

In a related series of experiments, certain effects ascribed by others to short-term memory storage for visual inputs are being reinvestigated. It has long been known that the immediate memory span for a briefly presented array of letters or digits can be improved by appropriate pre-exposure instructions, e.g., by directing the subject's attention to certain features in the display. Much more recently, the technique of post-stimulus cueing has been introduced: for instance, brief but intensely luminous exposures of arrays of letters are followed after variable intervals by exposure of an arrow pointing at the position previously occupied by a particular letter. Depending on the time interval between test letter and marker, improved selective recall of the letter may be demonstrated. However, recent work in these laboratories (Schiller, in progress) suggests that the effects in question are due to the persistence and decay of after-images rather than to short-term memory storage, as claimed.

C. Human Learning

During the period under review, work on human learning within this program has continued to center around short-term memory (see Norman and Wickelgren, 1965; Wickelgren, 1964a,b, 1965a,b,c). In addition, work on a two-stage model of discrimination learning applicable to various subhuman species and man has been nearly completed and the process has been simulated on a computer (Sutherland, 1964, 1965a,b; see also, for a contribution to decision theory, Becker and Wickelgren, 1965).

The most recent experiments on short-term memory (Wickelgren, in progress) comprise the following three studies: (a) Normal adult observers were asked to compare pure tones of slightly different frequencies with varying delays between the standard and the comparison tone. Detectability of pitch differences decreases with increasing delay between standard and comparison tones; curves were

obtained describing the observers' operating characteristics under these conditions. The interval was filled with an interfering (irrelevant) tone in order to make rehearsal during the delay period difficult or impossible. Under these conditions, the progressive decline in accuracy of comparison with lengthening delays suggested an exponential decay of the strength of the memory trace for the standard tone. By the same technique, it could be shown that increasing the length of the standard tone from one to eight seconds systematically improved the accuracy of the comparisons.

(b) Short-term memory was also investigated for triplets of digits, with recognition depending on varying serial positions and lengths of lists. The results again led to the conclusion that the strength of the underlying memory trace decays exponentially. It should be noted that most of the previous investigators did not find clear evidence for such exponential decay, probably because their experimental analysis did not discount the effects of response bias.

(c) During the last few months, strong evidence has been obtained that verbal items in short-term memory are coded in terms of phonemes; in turn, these phonemes are coded in terms of their distinctive features, a finding established by extensive testing of recall for lists containing different vowel phonemes. This work makes contact with those ongoing studies in our third major area of endeavor which deal with psycholinguistics - specifically, the efforts at obtaining evidence for the psychologic reality of linguistic structures (see below).

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III. Comparative and Developmental Studies

In this third area of endeavor, investigations are concentrated on ontogenetic and phylogenetic comparisons. Thus, the laboratories are trying to gain insights into early stages in the emergence of perception, skilled movements, or higher functions, such as concept attainment.

A. Comparative Studies

During the period under review, the laboratories have continued to explore behavioral repertoires of widely dissimilar species, in an attempt to correlate evolutionary changes in CNS structure with corresponding changes in behavior. In particular, we hope to elucidate some of the mechanisms in perception, memory or motor control by turning to those species whose morphology might provide unusual opportunities for analysis.

Accordingly, reports have been prepared and experiments undertaken on such diverse forms as the octopus (see Sutherland, Mackintosh and Mackintosh, 1965), goldfish (Ingle, 1965a, b), tree shrew (Tupaia, see Leonard and Gross, in progress), and hamster (Schneider and Gross, 1965).

1. Invertebrates. Highly organized marine invertebrates with image-forming eyes, such as the octopus, have long been considered as particularly opportune species for detection of innate form analyzers in visualsystems. Moreover, the visually-guided hunting of these species provides an excellent basis for testing the cross-species generality of certain laws of learning (Sutherland, 1964; Sutherland, Mackintosh and Mackintosh, 1965).

2. Fish. The visual system of a primitive vertebrate, such as the goldfish - with its laterally placed eyes and complete crossing of the optic nerves - provides similar opportunities for exploring certain neural bases of perception and learning. Numerous experiments have been undertaken in order to clarify the ways in which the two monocular fields of the fish appear to be independent under some conditions, and interdependent under other conditions, in the recording and recall of visual information (Ingle, 1965a,b).

3. Tupaia. Work on the Indonesian tree shrew (Tupaia glis) has proceeded in the recent past by continued application of behavioral tests ordinarily applied to monkeys, in order to compare and contrast the behavior of the tree shrews with that of regular primates such as the stumptail Macaque. Tupaia presents a baffling problem to taxonomists, having been classified first with insectivores, then more recently with primates. It may well turn out that the tree shrew does not belong with either order, but represents an extremely ancient and relatively unspecialized form of placental mammal. Capacity for acquiring visual discrimination "learning sets" has frequently been considered as providing a taxonomic marker. Accordingly, learning-set data have been compared for Rhesus monkeys (Macaca mulatta), stumptail macaques (Macaca speciosa), and for the tree shrews in our colony (Tupaia glis). The two species of true monkeys (stumptail and Rhesus) showed roughly equal capacity for set-learning (improvement across blocks of trials), while the tree shrews failed to show significant intertrial improvement.

4. Hamster. Until recently, studies on visually-guided behavior in hamsters, in these laboratories, have been concerned with the role of exploratory drive in

maze running. It could be shown that these animals will actively seek novel objects; on the other hand, they traverse a runway less readily if objects presented in the goal box have become familiar through prior exploration (Schneider and Gross, 1965). These experiments will now be combined with observations in large terraria providing quasi-natural environments. Attempts will also be made to test whether surgical destructions in the region of the superior colliculi and subjacent structures would interfere with visual exploration or, possibly, with visual recognition. Positive findings would be in line with repeated claims that lesions of tegmental structures in the mammal might produce a form of agnosia. Furthermore, these same hamsters will be observed for possible changes in their circadian rhythms, since such activity cycles are particularly well known for this species. It is hoped that these experiments might provide clues to the solution of a persistent problem, viz., the functions of the phylogenetically old portions of the mammalian visual system in the midbrain, i.e., those neural structures which in fish and bird appear to represent the principal substrate of vision.

B. Developmental Studies

Investigations of early stages in the development of perception and sensorimotor coordination continue to be concerned with the role of action in perception. Thus, we have made further attempts at fractionating the perceptual dysfunction induced in kittens raised under experimental conditions which preclude active locomotion, and we have begun to restudy the normal stages in the emergence of eye-hand coordination and other aspects of voluntary motor function in baby monkeys and in human infants. The gradual emergence of more complex achievements such as language has likewise been studied in normal children, in children raised under conditions of severe environmental deprivation, and in children with congenital brain injuries. Lastly, as in the past, there have been efforts at refining methods for assessing the acquisition of syntax or logic, and of social values throughout later childhood and early adolescence. Since recent progress reports have dealt with this portion of our program rather briefly, the pages that follow attempt to cover this area in greater detail.

1. Sensorimotor Development

a. Further studies of perceptual development in newborn kittens. Earlier observations on kittens deprived of active locomotion had suggested that visual perception of patterns and depth might be impaired by such restricted rearing. However, it was not clear whether active eye and head movements, in the absence of whole-body locomotion might suffice for the emergence of normal sensorimotor coordination. Current experiments in these laboratories (Hein and Held, and collaborators, in progress), suggest that fractional deprivation of opportunities for active movement during early postnatal development in kittens, may in turn lead to fractional deficits in perception. Thus, kittens were raised in holders which allowed them to swing their heads and see their forelimbs but prevented whole-body locomotion. Visible objects were placed at different distances from the kittens' eyes (4, 6 and 8 inches, respectively, for different groups of kittens). Following daily exposure of this type after several weeks, the kittens were tested for the presence of visual placing, pursuit movements of head, eyes, and forelegs in response to a moving object, and reactions on a "visual cliff." Thus far, abnormalities in pursuit of objects and on the "visual cliff" have been demonstrated for these kittens; their visual placing reactions appear normal on approach to a solid surface (visually triggered placing); abnormalities are revealed, however,

when the kittens are required to place their paws under visual guidance onto small protrusions from a serrated table edge.

b. Normative studies of early sensorimotor development in monkeys. In spite of the promising results obtained from the study of carnivores, the ontogeny of reaching movements and of eye-hand coordination can be assessed more readily in primates with prehensile limbs. For this reason, the laboratories are breeding stumptail macaques whose early sensorimotor development is observed and tested from day to day after birth. A first group of such monkeys, comprising four born in the laboratory 3-4 months ago, have now been joined by two more recent births. These longitudinal studies are so far addressed at obtaining norms for the appearance of pupillary and optokinetic responses, pursuit tracking with eyes, flexible accommodation and convergence, visually-guided reaching, etc. Most of these responses appear quite early, that is within the first 10-12 days, perhaps not surprisingly so, in an animal which climbs unaided a few days after birth. Nevertheless, blink responses to approaching objects have not been observed for the first two weeks. These normative studies are preliminary to various experimental manipulations of the early visuomotor experience of such very young primates.

c. Development of visual accommodation in human infants. Recent studies by others on preferential fixation by human infants on various bidimensional patterns (e.g., the work of Fantz, and of Hershenson) have yielded somewhat conflicting results, partly because of continued uncertainty about the extent and limits of visual resolution by the infantile visual system. One of the obviously limiting functions is accommodation, but this has not been subjected to appropriate early and systematic study. By applying dynamic retinoscopy to 22 normal infants ranging in age from 6 days to 4 months, it has now been established (Haynes, White and Held, 1965) that accommodation is at first fixed at a median distance of 19 cm., with flexibility of accommodative response gradually appearing around the middle of the second month. Accommodation performance comparable to normal adults is reached by the 4th month. The fact that the accommodative system does not respond adaptively to varying target distance before the second month of infancy puts important restrictions on visual experimentation with younger infants.

d. The evolution of reaching movements in the normal infant. It has often been said that prehensile activity in the normal human neonate is characterized by a strong involuntary "grasp reflex" which disappears pari passu with the evolution of voluntary grasping. In a study of reflexes of the upper limb in 500 infants from birth throughout the first year of life (Twitchell, 1965a, b), evidence has been obtained for a very different but orderly sequence of automatisms beginning at birth in the full-term infant, with an irregular alternation between tactually-triggered avoiding responses of the hand and a traction response consisting of a flexor synergy of the upper limb elicited by traction on the shoulder adductors. By contrast, the true grasp reflex does not appear until the age of 4 weeks; it consists of flexion adduction of the fingers and is elicited by contact stimulation to the palm. Lastly, an "instinctive grasp reaction" supervenes between 4-10 weeks after birth; this reaction - again to palmar contact - appears as a complex exploratory and prehensile movement of the infant's hand. The regularity of this ontogenetic sequence is astonishing, as is the fact that "voluntary" guided prehension "arises" out of those automatisms, as if the latter were a necessary "substrate." Yet the problem of what makes movements "voluntary." in physiologic terms, remains as acute as ever. Somehow, the infant "achieves control" over its own automatisms, but it is not at all clear what central changes have

to take place in order to transform reflexive into projected movements. The problem is all the more puzzling, since our work on perceptual development (Held, Hein, and others in the laboratories) has pointed at a crucial role of self-produced (i.e., voluntary) movement in the emergence of normal space perception.

e. Abnormalities of human development in the presence of early CNS damage. Studies of brain damage incurred at birth or earlier (Twitchell, 1964; Rudel, 1965) continue to reveal a characteristic pattern of arrest of motor development at stages normally overcome quite early in life. Thus, we observe abnormal persistence of avoiding or traction response, or only partial emergence of grasping automatisms which the brain-injured child employs in manipulating objects instead of the prehensile movements of the normal child. Work is in progress to determine how children who acquire this "control" over their persisting automatisms differ from those who do not, and to determine what role, if any, is played by sensory deficits in the various forms of motor retardation (work in progress: Twitchell, Corkin, Rudel and Teuber). Apparently, striking dissociations can occur: infantile hemiplegias are accompanied by exquisite sensitivity of the paralyzed hand (Rudel, in progress), in contrast to the preponderant combination of sensory and motor loss in the adult whose injury has been sustained later in life. At the same time, early brain injury seems to produce almost invariably a severe disturbance in the acquisition of orientation to the child's own body (Rudel, 1965).

f. Effects of early deprivation on human sensorimotor development. Efforts have continued to delineate those forms of sensorimotor retardation which are induced in physically normal infants by rearing under relatively deprived conditions in an orphanage-type nursery environment (White, 1965; White and Castle, 1964; White, Castle and Held, 1964). It has become clear that the absence of handling, and the comparatively monotonous sensory environment of these children produces delays of two months or more in the appearance of "voluntary" prehension. Various forms of experimental enrichment of these monotonous rearing conditions have now been employed, and their effect on development compared, e.g., enrichment by increased daily handling of the infants (White and Castle, 1964), by prone positioning, or by the display of mobile or stationary toys (White, 1965; White, Castle and Held, 1964). By such methods, the environmentally-induced delay in sensorimotor development could be diminished by as much as 6-1/2 weeks, even though some residual retardation seems to remain. Of particular interest is the time-gap between the appearance of accurate "swiping" of the fisted hand toward an object and its fairly dexterous prehension. This interval amounted, on the average, to 10-1/2 weeks in the original deprived groups and to 4 weeks in the enriched groups. Yet in both types of groups swiping movements preceded prehension. It will remain for the future to see whether the initial conditions of deprivation which we encountered in that setting about two years ago will have any lasting influence on the development of more complex achievements such as the acquisition of language.

2. Acquisition of Language, Logic and Social Values

a. Normal and abnormal language development in children. During the period under review, beginnings have been made in the weekly recording of infant vocalizations, with several normal children, from the first week of life through weekly half-hour tape recordings to the end of their second year (Lackner, in progress). These tapes should permit us to trace the transition from vocalization to verbalization, and should form a basis for a rigorous test of the view that phonemes are mastered in a regular sequence by a process of learning contrasts producing a

logarithmic growth. The same and related material should permit tests of various hypotheses about the normal acquisition of syntax (see also Bever, 1964; Fodor and Katz, 1964; Teuber, 1964a, b).

These normative studies should also yield a better measure of language retardation, as seen in deprived or brain-damaged children. The latter, in turn, can be studied as special cases of slow-motion exposure of normally transitory stages in language development. Lastly, these psycholinguistic studies of normal and retarded children should permit us to assess the extent to which language may help (or hinder) in the performance, by children, of a variety of tests involving complex discrimination or concept attainment (Rudel and Teuber, 1964; Schiller, 1965; Wickelgren, 1964, 1965).

b. Studies of apprehension of syntax. The studies just described are primarily concerned with stages in the capacity for linguistic expression; much less has been done so far in most quarters on the equally urgent problem of language comprehension. It is likely that children master certain critical distinctions between phonemes, receptively, long before they can produce these distinctions. However, this presumed difference in the timing of receptive and expressive capacities has never been measured - in part, undoubtedly because of the considerable practical difficulties in demonstrating the receptive capacities of very young children. Yet the question of relative timing of receptive and expressive linguistic distinctions has rather general importance. Many approaches to first language learning invoke the notion of analysis by synthesis, and this notion is often put in more concrete terms by saying that phonetic distinctions are acquired by making them, rather than by passive listening. Yet if distinctions can be heard by the child before they are made, these more concrete formulations of an "analysis by synthesis" approach are called into question.

Accordingly, considerable effort has been expended to devise nonverbal indicators of reception and discrimination of linguistic material. In previous reports, we have described the use of certain binaural listening tasks in this connection: an adult listens to sentences, of varying syntactic complexity, presented through an earphone, while the other earphone presents a brief (10 millisec.) click, placed at some random position within the sentence. Under these conditions, the position of the click in time is reported with a systematic error; the sign and size of the error depend (a) on whether the right or left ear received the click, and (b) on the actual location of the click with regard to the nearest syntactic junction point, there being a strong tendency to displace the click toward a syntactic junction. So far, verbal report of the perceived location of the click has been needed to demonstrate this phenomenon. It is therefore possible that the apparent shift in the location of the click is only found under conditions of reproduction or recall of what has been heard, or, differently put, it is conceivable that the shift does not yet occur while one is listening to the sentence. Nevertheless, the phenomenon has shown its usefulness if one employs the click as a "probe" for the listener's comprehension of the syntax. Thus, sentences with syntactic ambiguity will produce one or another shift in apparent location of the click depending on how the syntax has been perceived. On the other hand, these observations cannot be made in young children, since their verbal recall of any complex sentence is limited.

During the last several months, considerable efforts have therefore been made to utilize conditional galvanic skin responses as indicators as to "where" (i.e.,

"when") a click is being heard within a sentence. The experimental question is, of course, whether a galvanic skin response conditioned to the click would show a shift that might correspond to the shifts obtained under analogous circumstances upon verbal recall. If the technique can be worked out (present indications are that the GSR to click might be suppressed near or at syntactic junctions), then one might have a powerful tool for probing the receptive syntax of small children. Similarly, the technique could be extended for exploration of phoneme perception in very young children, such as determinations of the range of perceived similarities with series of phonemes that differ objectively along various phonemic dimensions.

c. Studies in the acquisition of social norms. As in the past, studies of child development in our laboratories have not been limited to consideration of sensorimotor and linguistic levels, but have extended beyond these to selected problems in the acquisition of norms and values. By testing children and young adolescents of different ages and either sex in laboratory situations involving a series of judgments, the stability or plasticity of norms can be assessed. The children are shown arrays of dots - too numerous to count - and asked to provide numerical estimates, with or without exposure to judgments of the same array purportedly made by their peers. The results continue to indicate an unexpected dissociation between the effects of such social influence on the judgments made within a given series of trials and on those made afterwards on another series of trials during which no further communications are received by the child. Apparently, strong within-trial effects of social influence are characteristic for girls of certain ages, together with a surprising evanescence of these effects (no persistence of social effects on later trials run without any further suggestions). Conversely, boys appear to show less within-trial effects - as though more resistant to immediate influence - but reveal rather marked effects on subsequent trials, a type of reaction suggesting "delayed compliance." These studies will be extended to earlier and later ages, and to different groupings of peers (boys with boy, girls with girls, and boys as sources of influence for girls, and vice versa).

The acquisition of standards of social norms for the judging of certain situations represents a central aspect of "socialization." In the course of normal development outside the laboratory, children assimilate social norms predominantly by induction, on their own part, and less through exposure to explicit exhortation. In this respect, the early acquisition of norms may not be too dissimilar from the acquisition of syntax in first-language learning, and it may not be too much to hope that studies illuminating one type of early development may also illuminate the other.

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